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MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2016/2017

EPM2036 – CONTROL THEORY (All Sections / Groups)

01 JUNE 2017
2:30 p.m. - 4:30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This Question paper consists of 5 pages including cover page with 4 Questions only.
2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please write all your answers in the answer booklet provided.

Question 1

- (a) A control engineer, N.Minorsky, designed an innovative ship steering system in 1930's for the U.S. Navy. The system is represented by the block diagram shown in Fig. Q1 (a), where $Y(s)$ is the ship's course and $R(s)$ is the desired course.

- (i) Determine the transfer function $Y(s)/R(s)$, using block diagram reduction technique.
- (ii) Draw the signal flow graph.

[12 + 3 marks]

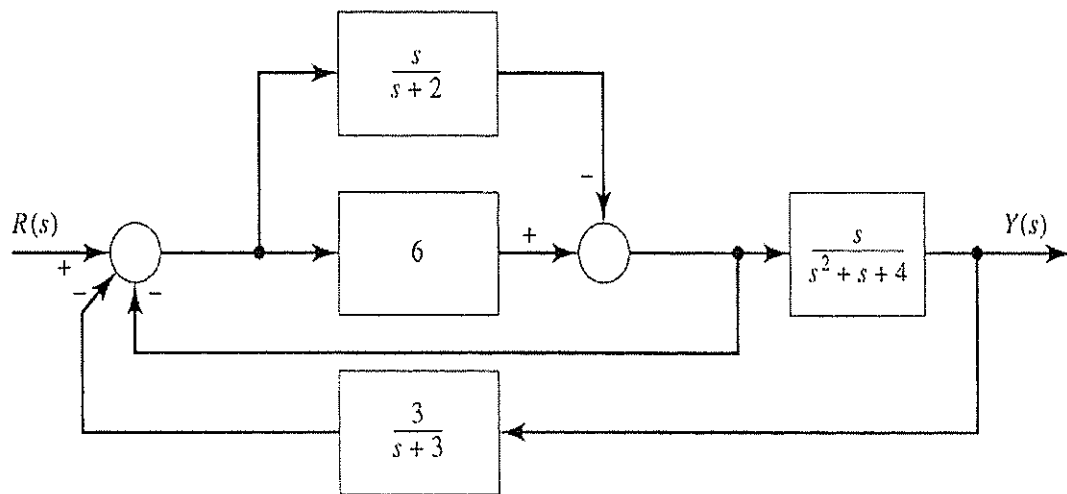


Fig. Q1 (a)

- (b) Determine the transfer function of $G(s) = \theta_2(s)/T_1(s)$ for the mechanical system shown in Fig. Q1 (b). (Hints: assume zero initial condition)

[10 marks]

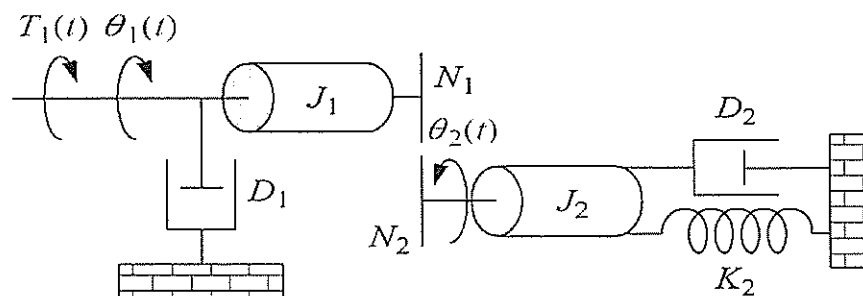


Fig. Q1 (b)

Continued...

Question 2

- (a) Given the forward-path transfer function of a unity feedback system

$$G(s) = \frac{50}{s(s+10)}$$

For the unit step response of the system, determine the natural frequency, damping ratio and settling time for 2% error.

[6 marks]

- (b) Given the forward-path transfer function of a unity feedback system

$$G(s) = \frac{81}{s(s+K)}$$

- (i) Determine the value of K , if the unit step response of the system is critically damped.

[5 marks]

- (ii) If $K=18$ determine the position constant K_p velocity constant K_v and acceleration constant K_a .

[6 marks]

- (c) Consider the characteristic equation of a LTI system.

$$F(s) = s^4 + s^3 - 5s^2 + 2s + 6 = 0$$

- (i) Determine the stability of the system using Routh Hurwitz criteria.
(ii) Determine the number of roots in the right-half of s-plane.

[6+2 marks]

Continued...

Question 3

(a) A negative unity feedback system has a forward path transfer function $G(s)$ given by

$$G(s) = \frac{K(s+5)}{s(s^3 + 4s^2 + 6s + 4)}$$

For the root locus plot, determine the following:

(i) Starting and ending points of all branches

[2 marks]

(ii) Imaginary axis crossing points and the corresponding K value

[5 marks]

(b) Consider the feedback control system shown in Fig. Q3 (b).

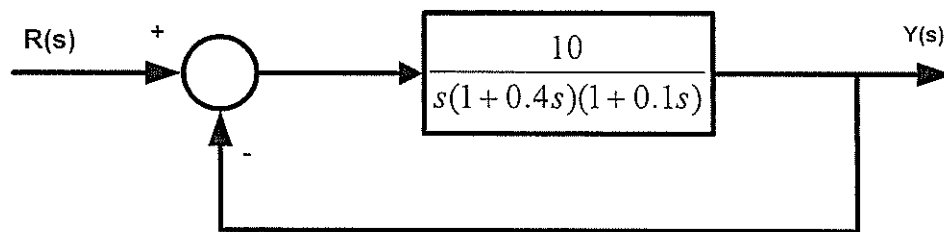


Fig. Q3 (b)

Plot the *Bode* magnitude plot of $G(s)$ in the semi-log paper.

[18 marks]

Continued...

Question 4

- (a) Show how a Proportional-Derivative (PD) controller can be realized with only two op-amps.

[5 marks]

- (b) A process has a transfer function $G_p(s) = \frac{1}{s+5}$. The process is to be controlled in closed-loop using a Proportional-Integral (PI) controller. Design the controller such that the steady-state error in response to a ramp input is 10% of the magnitude of the ramp. The closed-loop zero should be placed at -10 .

[10 marks]

- (c) A particular system has a forward path transfer function:

$$G(s) = \frac{5}{(s+1)(s+2)}$$

A Proportional-Integral (PI) controller is applied to control the system $G(s)$. Find the range of values of the integral constant (relative to the proportional constant) in order for the closed-loop system to be stable.

[10 marks]

End of Paper